Amendments to the Claims

1. (Original) A process for forming a copper interconnect in a substrate including a connect hole vertically extending through an inter-level dielectric layer, comprising the steps of:

a first step, performed at least partially by atomic layer epitaxy, of depositing a barrier layer comprising tantalum on sides of said hole;

a second step, performed by physical vapor deposition, of depositing a copper seed layer over said barrier layer; and

filling by electrochemical plating copper into said hole over said copper seed layer.

2. (Original) The process of Claim 1, wherein said barrier layer comprises tantalum nitride.

3. (Original) The process of Claim 1, further comprising a third step performed between said first and second steps of etching said barrier layer at the bottom of said hole.

4. (Original) The process of Claim 3, wherein third step includes generating an argon plasma and biasing a pedestal electrode supporting said substrate to attract argon ions to said substrate, thereby etching said barrier layer.

5. (Original) The process of Claim 4, wherein said generating step includes inductively coupling RF power into a plasma reactor containing said pedestal electrode.

6. (Original) The process of Claim 1, wherein said first step includes an initial CVD step for depositing a first part of said barrier layer and a subsequent sputtering step for depositing a second part of said barrier layer.

7. (Original) A process for forming a copper interconnect in a substrate including a connect hole vertically extending through an inter-level dielectric layer, comprising the sequentially performed steps of:

a first step, performed by chemical vapor deposition, of depositing a first barrier layer comprising tantalum on sides of said hole;

a second step, performed by sputtering, of depositing a second barrier layer comprising tantalum on said sides of said hole;

a third step, performed by physical vapor deposition, of depositing a copper seed layer over said first and second barrier layers; and

a fourth step, performed by electrochemical plating, of filling copper into said hole over said copper seed layer.

8. (Original) The process of Claim 7, wherein said chemical vapor deposition comprises atomic layer epitaxy.

9. (Original) The process of Claim 7, further comprising a fifth step performed after said first step performed in a sputter reactor of etching said first barrier layer at the bottom of said hole.

10. (Original) The process of Claim 9, wherein fifth step includes generating an argon plasma and biasing a pedestal electrode supporting said substrate to attract argon ions to said substrate, thereby etching said barrier layer.

11. (Original) The process of Claim 10, wherein said generating step includes inductively coupling RF power into a plasma reactor containing said pedestal electrode.

12. (Original) The process of Claim 7, wherein said chemical vapor deposition comprises atomic layer epitaxy.

13. (Original) A process for forming a copper interconnect in a substrate including a connect hole vertically extending through an inter-level dielectric layer, comprising the steps of:

depositing by a deposition process comprising chemical vapor deposition a nitrided barrier layer on sides of said hole;

in a sputter reactor including a tantalum target, etching said nitrided barrier layer on a bottom of said hole;

in said sputter reactor, depositing a material comprising tantalum on sidewalls of said hole to form a second barrier layer;

depositing by physical vapor deposition a copper seed layer over said second barrier layer; and

filling by electrochemical plating copper into said hole over said copper seed layer.

14. (Original) The process of Claim 13, wherein said deposition process comprises atomic layer deposition.

15. (Original) The process of Claim 13, wherein said nitrided barrier layer comprises TiSiN.

16. (Original) The process of Claim 13, wherein said second barrier layer comprises TaN.

17. (New) A method of filling one or more of a via and a trench in a patterned substrate, comprising:

a) depositing a generally conformal first barrier layer in one or more of the via and the trench on the patterned sbustrate by chemical vapor deposition, wherein the first barrier layer comprises a silicided nitride of a refractory metal selected from the group consisting of Ti, Ta, and W;

b) removing the first barrier layer from horizontal surfaces of the patterned substrate;

c) depositing a second barrier layer by physical vapor deposition; and

d) then depositing one or more conductive materials.

18. (New) The method of Claim 1, wherein depositing the conductive material comprises depositing a seed layer and a metal layer in the via and/or the trench after the second barrier layer is deposited.

19. (New) The method of Claim 18, wherein the first barrier layer comprises a material is selected from the group consisting of Ti, Ta, W, and nitrides thereof.

20. (New) The method of Claim 1, wherein the second barrier layer comprises at least one refractory metal selected from the group consisting of Ta and W.

21. (New) The method of Claim 18, wherein the seed layer comprises copper.

22. (New) The method of Claim 21, wherein the metal layer comprises is copper.

23. (New) The method of Claim 17, wherein the first barrier layer is deposited and removed from horizontal surfaces of the patterned substrate within a single chamber of an integrated processing tool.

24. (New) The method of Claim 23, wherein the chamber is a chemical vapor deposition chamber and the first barrier layer is deposited and etched in a sputter chamber.

25. (New) The method of Claim 18, wherein the seed layer is deposited by physical vapor deposition.

26. (New) The method of Claim 18, wherein the metal layer is deposited by chemical

vapor deposition.

27. (New) The method of Claim 18, wherein the metal layer is deposited by electroplating.

28. (New) The method of Claim 17, wherein the second barrier layer comprises a material selected from the group consisting of Ta, TaN, W, WN, Ti, and TiN, and wherein the second barrier layer has a thickness of from about 2nm to about 5nm at the bottom of the via.

29. (New) A method of filling one or more holes in a patterned substrate, comprising:

a) depositing a generally conformal first barrier layer on the patterned substrate by atomic layer deposition;

b) removing the first barrier layer from horizontal surfaces of the patterned substrate;

c) depositing a second barrier layer by physical vapor deposition; and

d) then depositing one or more conductive materials to fill the holes.

30. (New) The method of Claim 29, wherein depositing the conductive material comprises depositing a seed layer and a metal layer in the holes after the second barrier layer is deposited.

31. (New) The method of Claim 30, wherein the first barrier layer comprises a material selected from the group consisting of Ta, TaN, W, and WN.

32. (New) The method of Claim 31, wherein the second barrier layer comprises a material selected from the group consisting of Ta, TaN, T, TiN, W, and WN.

33. (New) The method of Claim 32, wherein the seed layer comprises copper.

34. (New) The method of Claim 33, wherein the metal layer comprises copper.

35. (New) The method of Claim 30, wherein the seed layer is deposited by physical vapor deposition.

36. (New) The method of Claim 30, wherein the metal layer is deposited by electroplating.

37. (New) The method of Claim 29, wherein the second barrier layer comprises a material selected from the group consisting of Ta, TaN, W, WN, Ti, and TiN.

38. (New) A method of filling one or more of a via and a trench in a patterned substrate, comprising:

a) depositing a generally conformal first barrier layer on the patterned substrate by chemical vapor deposition;

b) removing the first barrier layer from the horizontal surfaces of the patterned substrate;

c) depositing a second barrier layer by physical vapor deposition; and

d) then depositing one or more conductive materials.

39. (New) The method of Claim 38, wherein depositing the conductive material comprises depositing a seed layer and a metal layer in the via and/or the trench after the second barrier layer is deposited.

40. (New) A method of filling one or more of a via and a trench in a patterned substrate having a metal layer underlying the via, comprising:

a) depositing a generally conformal first barrier layer on the patterned substrate by chemical vapor deposition, wherein the first barrier layer comprises a silicided nitride of a refractory metal selected from the group consisting of Ti, Ta, and W;

b) removing the first barrier layer from horizontal surfaces of the patterned substrate;

c) depositing by physical vapor deposition a second barrier layer sufficient to provide a barrier on the bottom of the trench; and

d) then depositing one or more conductive materials.

41. (New) A method of filling one or more of a via and a trench in a patterned substrate having a metal layer underlying the via, comprising:

a) depositing a generally conformal first barrier layer on the patterned substrate by atomic layer deposition;

b) removing the first barrier layer from horizontal surfaces of the patterned substrate;

c) depositing by physical vapor deposition a second barrier layer sufficient to provide a barrier on a bottom of the trench; and

d) then depositing one or more conductive materials.